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Protection of the Atmosphere*

Report of the Secretary-General

Contents

		Paragraphs	Page
I.	Introduction	1–4	3
II.	Global factors	5–17	3
	A. Greenhouse gases	6–12	4
	B. Protection of the ozone layer	13–17	5
III.	Regional and local factors	18–39	6
	A. Transboundary air pollution	18–32	6
	B. Urban air pollution	33–39	8
IV.	Climate change and climate variability	40–62	9
	A. Linkage between climate change and variability	41–42	9
	B. Role of systematic observations	43–45	10
	C. Impacts of climate change and variability on human health	46–51	10
	D. Climate impact assessment	52–59	11
	E. Vulnerability and adaptation assessment	60–62	12

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V. The way forward: recommendations for reducing vulnerability, strengthening resilience and building adaptive capacity 63–71 13

A. Capacity-building 66–68 13

B. Education and training 69–70 14

C. Public awareness 71 14

I. Introduction

1. In accordance with its multi-year programme of work, adopted by the General Assembly at its nineteenth special session, the Commission on Sustainable Development will consider at its ninth session issues related to the protection of the atmosphere. Chapter 9, Protection of the Atmosphere, of Agenda 21 is concerned with several facets of human activity that modify the atmosphere, leading to natural adjustments that are expected to result in negative economic and social consequences. The purpose of the present report is to focus on those aspects of human activity with impacts on the atmosphere other than those resulting directly from energy generation and consumption, which are addressed in the reports of the Secretary-General on energy and sustainable development to the Ad Hoc Open-Ended Intergovernmental Group of Experts on Energy and Sustainable Development (E/CN.17/ESD/2000/3 and E/CN.17/ESD/2001/2).

2. The earth's atmosphere must be considered as one of three basic, interacting domains that comprise the "earth system environment" — the other two being the oceans and the land surface, each with its own high level of complexity. This fact highlights the need to consider the present report in the broader context of the other Agenda 21 chapters — namely, those in section I, Social and Economic Dimensions, and in section II, Conservation and Management of Resources for Development. A further consideration in the preparation of this report is that sustainable development is inextricably linked with the impact that variations in the atmosphere itself can have on human activity. Since complex adaptive systems, such as the earth's environment, are by their nature replete with variability, it is essential to understand as much as possible how changes on all time scales can occur within the system. This is a prerequisite to understanding and identifying the effects of human activity on the atmosphere and to devising effective actions to mitigate and possibly reverse negative impacts.

3. There is considerable activity under way relevant to this report which was stimulated by environmentally related programmes and conventions, both preceding and following the 1992 United Nations Conference on Environment and Development. In particular, the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer have laid down a framework for halting and reversing the depletion of stratospheric ozone through mandated reductions in the emission of ozone-depleting chemicals into the atmosphere. In addition to the United Nations Framework Convention on Climate Change (FCCC)[1], the Convention on Biological Diversity[2] and the Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa[3], are also relevant, but actions under those programmes and conventions must be harmonized to ensure that perceived benefits under one are not achieved at the expense of deleterious consequences for another. In this connection, efforts are continuing in the United Nations Environment Programme (UNEP) to facilitate synergies between the various multilateral environmental agreements (MEAs) and between those MEAs and regional agreements and action plans. The purpose is to encourage a full and integrated approach to addressing environmental issues, recognizing that they are inextricably linked through their drivers — namely, human demands on the environment.

4. Specific efforts at integrated national reporting to realize cost-effectiveness are continuing. As an example, collaboration between global conventions such as FCCC and Regional Seas Conventions and Action Plans could improve the effectiveness of delivery of response measures to anticipated impacts of climate change. In the review of chapter 9 at its fourth session (E/CN.17/1996/22 and Add.1), the Commission considered mainly the energy aspects of the issue and the efforts in place to address them. Although chapter 9 was again reviewed by the Commission at its fifth session (E/CN.17/1997/2/Add.8) and by the General Assembly at its nineteenth special session, matters relating strictly to climate did not receive as much attention as they do in the present report.

II. Global factors

5. Significant progress has been achieved in addressing the uncertainties and improving the scientific basis for decision-making with regard to greenhouse gases and ozone-depleting substances. Although not yet released, the third assessment report of the Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: The Scientific Basis*, is reported to state that there is now stronger evidence for

a human influence on climate than at the time of the second assessment report (1995), and it is likely that increasing concentrations of greenhouse gases have contributed substantially to the observed global warming over the past 50 years. Moreover, IPCC is reported to have revised its earlier estimates of temperature increases by 2100 from an increase of 1-3.6 Centigrade degrees to an increase of 1.5-6 Centigrade degrees, due to the expected reduction of sulfur oxide emissions. Negotiations under the FCCC to address global climate change at the sixth session of the Conference of the Parties to the Convention, which deliberated in The Hague, Netherlands, in November 2000 on preparations for the implementation of the Kyoto Protocol[4], were suspended and are likely to resume in May or June 2001.

A. Greenhouse gases

1. Status of the atmospheric build-up of greenhouse gases and implications for climate change

6. The increases in the atmospheric concentrations of carbon dioxide and several other greenhouse gases continue to give cause for widespread concern. In particular, the concentrations of the anthropogenic greenhouse gases (mainly carbon dioxide, methane, nitrous oxide and the halocarbons) all rose sharply over the past 100-200 years, and more rapidly so in recent decades. These increases are largely connected with energy generation, transport and agriculture. They will significantly change the balance between incoming solar radiation and heat radiated back out into space, resulting in global warming and consequent global and local climate changes and a rise in sea level. There is justifiable concern that the predicted rates and magnitudes of these changes will have serious impacts on the environment, the economy and society in general.

7. The IPCC report notes that the concentration of atmospheric carbon dioxide has now risen to over 360 parts per million from a pre-industrial level of about 270 parts per million. The change in the ratio of carbon isotopes in atmospheric carbon dioxide is evidence that this increase is due to human activities. Carbon dioxide has an effective lifetime in the atmosphere of about 100 years, so its global mean concentration responds only very slowly to changes in emissions. This means that about one third of the concentration change due to human activities today will still be present 100 years from now. Of the anthropogenic greenhouse gases, carbon dioxide makes the largest direct additional contribution to radiative forcing at present and is likely to do so for some time into the future. Stabilization of carbon dioxide emissions at current levels would slow down the consequential projected climate change but would still result in rising atmospheric concentrations. Emissions reductions of 60-70 per cent from current levels would be needed to prevent carbon dioxide concentrations from rising further.

8. Many of the other greenhouse gases also remain in the atmosphere for long periods (from many decades to centuries) and hence, like carbon dioxide, they affect climate forcing on long time-scales. About one quarter of the projected warming is expected to be due to methane, with other greenhouse gases making up the balance.

9. The work of the FCCC, and in particular the implementation of the Kyoto Protocol, will be crucial to reducing the emissions of greenhouse gases with the goal of stabilizing and ultimately reducing the atmospheric concentrations of these gases.

2. Progress on the development and use of climate models to determine scenarios or projections of future climate change

10. In climate modelling, a great deal of significant progress has been made since the first scientific assessment of IPCC in 1990. The climate models now being used for predicting climate change are based on mathematical representations of the physics and dynamics of the climate system and are becoming increasingly realistic in their simulations of recent climate. Also, understanding and quantification of the forcings that might cause climate change have been greatly improved. It has been clearly demonstrated in the more recent modelling studies, for example, that atmospheric aerosols also influence climate change at both the global and regional scales. Aerosols produce negative radiative forcing, and this effect has been captured in the modelling of climate, using general circulation models. Arguably, these recent new insights into human-induced climate change should increase the concern over global warming and climate change resulting from an enhanced greenhouse effect. Studies have increased confidence in modelling capabilities and re-emphasized the need to improve understanding of climate and its variability.

11. However, deficiencies and uncertainties remain, particularly in establishing the actual climate forcing to apply, the sensitivity of the models to different and new representations of the important climate processes and feedbacks, and in relation to natural versus human-induced climate variability. Also, incomplete understanding of the climate system means that there is need to investigate the possibility of rapid, non-linear changes in climate. International collaboration in the IPCC assessments and in the formulation and implementation of programmes such as the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP) enables problem areas to be identified and scientific priorities to be agreed. Indeed, the refinement of climate models remains a major unifying component of WCRP, requiring scientific and technical advances in a wide range of disciplines.

12. The status of systems for measuring the build-up of greenhouse gases in the atmosphere is described in the background document entitled, "Addressing the uncertainties: improving the scientific basis for decision-making".

B. Protection of the ozone layer

13. Substantial progress has been made in the realization of the objectives of the Vienna Convention and the Montreal Protocol, as amended. By July 2000, a total of 176 countries had ratified the Vienna Convention and 175 countries the Montreal Protocol.

1. Status report on measured effects of the Vienna Convention/Montreal Protocol on reversing stratospheric ozone declines

14. The abundance of ozone-depleting substances in the atmosphere can provide a measure for assessing the effectiveness of the Convention and the Montreal Protocol in reversing stratospheric ozone depletion. The total combined abundance of ozone-depleting compounds in the lower atmosphere peaked in 1994 and is now slowly declining. Total chlorine concentrations are declining, but total bromine concentrations are increasing, according to the Scientific Assessment Panel of the Montreal Protocol. Bromine is much more effective at destroying ozone than chlorine. Chlorine is declining because the total consumption of chlorofluorocarbons (CFCs) worldwide, about 1.1 million tons in 1986, had declined to 156,000 tons by 1998. The Parties to the Convention have phased out 85 per cent of the production of those chemicals that are responsible for destroying the ozone layer. The remaining 15 per cent are mainly produced and consumed in developing countries that have until 2010 to phase out most of the major ozone-depleting substances.

15. One measure of the success of the Montreal Protocol and its subsequent Amendments and Adjustments is that it has resulted in a decrease in the amount of ozone-depleting substances expected to be in the stratosphere in 2050 to 20 per cent of the value expected without the Protocol. Ozone depletion would have risen to 50 per cent in the northern hemisphere mid-latitudes and 70 per cent in southern hemisphere mid-latitudes, which are about 10 times worse than current levels. The result would have been a doubling of UV-B radiation reaching the earth in northern hemisphere mid-latitudes and a quadrupling in the southern hemisphere. The implications for human health would have been very serious: 19 million additional cases of non-melanoma skin cancer, 1.5 million more cases of melanoma, and 129 million more cases of eye cataracts. The Commission may wish to recommend that the critical ground-based measurement programme for total column ozone coordinated by the World Meteorological Organization (WMO) be strongly supported over the next decade in order to determine the potential net effects of ozone depletion.

16. The Multi-lateral Fund of the Montreal Protocol has made possible the earlier phase-out of ozone-depleting substances in developing countries; however, there is a need to continue replenishing the fund adequately for timely implementation of the Protocol, and thus the Commission may wish to invite donor countries to periodically and adequately replenish the Fund.

2. Global warming potentials of substitutes for ozone-depleting substances and options to reduce global warming contributions from substitutes for ozone-depleting substances

17. Ozone-depleting substances (ODSs), which include chlorofluorocarbons (CFCs), are being replaced by hydrofluorocarbons (HFCs) and to a lesser extent by perfluorocarbons (PFCs). HFC and PFC concentrations in the atmosphere are increasing, as they are the substitute group of chemicals for ODSs. HFCs and

PFCs have significant global warming potential (GWP) and the Kyoto Protocol of the FCCC has included HFCs and PFCs in a basket of six gases whose emissions are to be reduced by industrialized countries. The global warming potentials of ODS substitutes have been evaluated by the Panel for Scientific Assessment of the Montreal Protocol and IPCC. In addition, options to reduce global warming contributions from ODS substitutes have been evaluated by the Technical and Economic Assessment Panel (TEAP) of the Montreal Protocol and IPCC. Both Assessment Panels are working closely with IPCC to address the problem of HFCs and PFCs in the context of the two Protocols.

III. Regional and local factors

A. Transboundary air pollution

18. Actions to address national issues in a number of countries and agreements among those countries on a regional basis have led to some control of transboundary air pollution and its impacts. This long-range pollution can take the form not only of industrial and transportation emissions of sulphur dioxide, the nitrogen oxides, heavy metal compounds, volatile organic compounds, soot, and radioactive vapours, but also of the smoke, haze and soot of large forest and biomass fires. These emissions can result in freshwater acidification and eutrophication, forest dieback, high surface ozone levels, the accumulation of heavy metals and persistent organic pollutants in soil, water and living organisms as well as associated human health problems. Despite increasing industrialization and reliance on transportation, reductions have been achieved in emissions that cause acid deposition and tropospheric ozone.

19. In industrialized countries, the trend is towards continuous efforts to reduce the environmental impacts due to transboundary atmospheric pollution. The transport of air pollution across national boundaries has been an important environmental issue in Europe. The Convention on Long-range Transboundary Air Pollution (CLRTAP), which entered into force in 1983, and its Protocols aim to reverse damage to the environment. In North America, the issue of transboundary air pollution resulted in the Canada/United States Air Quality Agreement in 1991, and was included in the 1983 La Paz Agreement between Mexico and the United States for the protection, improvement and conservation of the environment along the United States/Mexican border.

20. More recently, the importance of transboundary air pollution has become an issue in many developing nations. In some regions, declarations and resolutions have been issued and studies and monitoring programmes initiated and implemented to address transboundary air pollution. The agreements include the Cañuelas Declaration on the Control and Prevention of Atmospheric Pollution in the countries of southern South America, the Harare Resolutions on the Prevention and Control of Regional Air Pollution in Southern Africa and Its Likely Transboundary Effects, and the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia. The monitoring programmes include the Acid Deposition Monitoring Network in East Asia, supported by the Government of Japan, the Regional Acidification Information and Simulations-Asia Programme, launched by the International Institute of Applied Systems Analysis, and the Programme to Address ASEAN (Association of South-East Asian Nations) Regional Transboundary Smoke and Haze in South-East Asia, initiated by the WMO and the United Nations Environment Programme (UNEP).

21. Nevertheless, given the rising levels of transboundary air pollution, the Commission may wish to recommend initiating and enhancing regional cooperation to reduce levels of such pollution. Examples of successful and promising efforts and important initiatives may be helpful in this regard.

1. European airborne pollution

22. The European Monitoring and Evaluation Programme (EMEP), established and being implemented in close cooperation with WMO, has been responsible for pollution monitoring and modelling within the European region for over two decades. During this period, EMEP has provided the scientific evidence required to develop reasonable environmental policies. The monitoring network, quality control system, emission data and modelling work have demonstrated the transboundary nature of pollution problems, making it possible to quantify the source/receptor relationships between countries and regions and have convincingly communicated the results to policy makers and to the public. The efforts under EMEP have facilitated the calculation of cost-optimal solutions that identify the emission reductions

needed for each country to ensure environmental improvements.

23. CLRTAP and EMEP are now at an important turning point. The Gothenburg Protocol and the Protocols on Heavy Metals and Persistent Organic Pollutants are due for ratification by the parties to CLRTAP within the next few years. These Protocols will require significant investments and structural changes within the acceding countries. EMEP should support national implementation of the Protocols by facilitating the exchange of information and scientific knowledge between parties. In addition, EMEP must develop mechanisms to verify that the international emission reduction agreements function as intended and guide the CLRTAP in further amending current policies and developing new ones.

2. Acid deposition

24. The measurement of the chemical composition of precipitation has been one of the basic components of observing systems for atmospheric chemistry studies. The main objectives in establishing a global network of monitoring stations were: (a) to ensure data collection on the basis of common methodologies; and (b) to evaluate background concentration levels of some chemical compounds in precipitation as well as their spatial and temporal distribution. From these measurements, some of the influences of human activities on the composition of the atmosphere can be assessed. The results of multi-year measurements of the chemical composition of precipitation were published by WMO in 1996 in a report entitled "Global acid deposition assessment". The WMO Global Atmosphere Watch (GAW) programme participates in and cooperates with a number of regional acid-deposition measurement programmes in Europe, North America and East Asia in a global-scale effort to harmonize these measurements and to ensure comparability of the data required for more detailed and precise global acid-deposition assessments.

25. At present, there are about 200 GAW precipitation chemistry stations distributed around the globe (16 in Africa, 30 in Asia, 7 in South America, 39 in North and Central America, 10 in the South-west Pacific, and 88 in Europe).

3. Regional pollution from industrialization and forest fires

26. WMO, the World Health Organization (WHO) and UNEP have played very active roles in assisting affected countries with the issue of forest fires in South-east Asia. For example, a summary of national and regional capabilities, to detect, monitor and track smoke and haze, including modelling and satellite capabilities, was obtained during an expert overview in 1996. This review resulted in the establishment of the Programme to Address ASEAN Regional Transboundary Smoke and Haze in South-East Asia, in June 1998.

27. The role of WMO is to assist in enhancing regional capabilities to provide meteorological support in the form of improved predictions of El Niño Southern Oscillation (ENSO)-driven climate variability, daily smoke trajectories and dispersion forecasts using atmospheric transport models. Activities are being promoted to improve the ability to characterize fire activity and to use remote-sensing methods to track the movement of smoke and haze. Assistance will continue to be provided to strengthen regional monitoring efforts and to improve the management of smoke and haze (and other transboundary) pollution events through enhanced information exchange and coordination.

28. A major activity spearheaded by WHO has a direct bearing on the topic of transboundary pollution as a result of fires: the WHO/UNEP/WMO Health Guidelines for Vegetation Fire Events. Vegetation fires, particularly uncontrolled ones, are a substantial source of air pollution in urban and rural areas. As such, they affect human health, economic activity, and contribute to rapid environmental change and degradation. The challenge is to ensure sustainable development and healthy living conditions. Poverty and uncontrolled logging, both of which lead to land clearing by burning, are at the centre of that challenge.

29. The forest fires induced by the 1997/1998 El Niño event brought to the fore a need for preparedness measures in responding to these fires. Through a Global Environment Facility (GEF)-supported project, UNEP was able to collaborate both with the United Nations Development Programme and the affected countries in mitigating the impacts of the fires as an emergency measure. Work is continuing through this project and other activities, such as the WMO Climate

Information and Prediction Services (CLIPS) project, towards building capacity by providing assistance to affected countries.

30. The Commission may wish to recommend the urgent need to further consider the development of a cooperative mechanism to establish a legal framework to prevent transboundary haze, which would help build a sense of responsibility and a mechanism for collaboration in dealing with such fires.

4. Radioactive releases

31. In the 10 years since the Chernobyl nuclear accident, significant advances in information and communication technologies have totally changed the environment in which decision makers would deal with radioactive release emergencies. In parallel, scientific advances in models that can track and predict dispersing plumes have also been made.

32. The Atmospheric Transport Model Evaluation Study (ATMES), jointly sponsored by the European Commission, WMO and the International Atomic Energy Agency (IAEA), has been carried out in recent years as a follow-up to joint activities on the validation of long-range atmospheric dispersion models using Chernobyl fallout information. In the subsequent European Tracer Experiment (ETEX), many characteristics of a real accident situation were simulated. This capability should prove to be useful to decision makers who must deal with future radioactive release emergencies from nuclear accidents.

B. Urban air pollution

33. An ever-increasing proportion of the world's population is living in urban environments, and this is especially evident in developing countries. Most energy is also consumed in urban environments, reflecting the rapid motorization and industrialization that goes hand in hand with the increase in population. These developments all too often result in deteriorating air quality as pollution levels rise. In most industrialized countries, measurable progress has been made in reducing levels of urban air pollution, where technology-based strategies have been mainly used to address the environmental impacts: applying controls to "smoke-stack" emissions and particularly, in the transportation sector, to motor vehicle emissions through the use of, for example, lead- and sulphur-free motor gasoline, and fuel additives and catalytic converters to reduce tailpipe emissions of gaseous pollutants. However, most developing countries do not have access to these technologies for reducing air pollution from motor vehicles, and efforts to reduce emissions from existing vehicles are thwarted by an increasing demand for more transportation. Issues related to transportation are further elaborated in the report of the Secretary-General on transport (E/CN.17/2001/3). In this regard, the Commission may wish to recommend enhanced international cooperation for the purpose of making the technology available to those developing countries with urban centres, which are severely affected by emissions of gaseous pollutants and fine particulate matter from the transportation sector.

34. Many national meteorological and hydrological services of WMO member countries have expressed interest in better managing the urban environment. The NMHSs are in possession of information and capabilities that are essential to the forecasting of urban air pollution and for the evaluation of the effectiveness of different control strategies. They are therefore essential partners in tackling this growing problem.

1. Standards for urban air quality

35. WHO issues air-quality guidelines, based on health studies, which are now applicable worldwide. An increasing number of Governments in the developing world are setting national air-quality standards. A growing body of evidence, obtained through measurements, indicates that many cities regularly exceed these guidelines and standards in both the industrialized and the developing world. Measures need to be taken to improve air quality to meet the guidelines and standards.

36. The Sustainable Cities Programme (SCP) of the United Nations Centre for Human Settlements (UNCHS/Habitat) and UNEP and WHO seeks to address this issue. In a number of cities participating in the Programme, air pollution has been identified as a priority environmental issue of concern. In those cities, citizens suffer widely from breathing difficulties and asthma caused by an unhealthy environment, and the issue has been prioritized for urgent attention. In order to address the issue, SCP working groups on air-quality management have been established in various cities. To guide cities, and especially the working groups, in this

process, SCP has developed an Urban Air Quality Management Handbook with a toolkit. In June 2000 in Salt Lake City, Utah (United States of America), it convened the International Conference on Urban Air Quality Management and Transportation Planning Issues. The method of energy generation employed is critical to improving the urban environment. This issue is further elaborated in the reports of the Secretary-General on energy and sustainable development (E/CN.17/ESD/2000/3 and E/CN.17/ESD/2001/2).The latter applies especially in developing countries where wood burning remains the primary source of domestic fuel.

2. International urban initiatives

37. To address the urban environment issue and assist the NMHSs of developing countries, WMO has recently established the GAW Urban Research Meteorology and Environment (GURME) project which aims to enhance the capabilities of the NMHSs in managing the meteorological and related aspects of urban pollution. GURME has been designed to do this through capacity-building and coordination between the different agencies concerned, ranging from city governments to health authorities.

38. The strategy for cooperation includes workshops to explore the various techniques available and their limitations for both atmospheric conditions and pollution forecasting as well as their measurement, computational and other system requirements. A second important thrust concerns the development of pilot projects. Within the past year, for example, GURME projects have been established in Beijing and Moscow. The aim of the projects in these two cities with significant pollution problems is to investigate the chemistry of air pollution formation, methods for predicting its course, measurement and monitoring requirements, user requirements for information, and mitigation strategies. It is expected that other cities will follow with their own projects.

39. Five major activities of WHO have a direct bearing on the topic of urban air pollution: the WHO Guidelines for Air, the Air Management Information System (AMIS), the update of the "Megacities" report, the estimation of the global burden of disease due to air pollution, and research on particulate matter and health implications. These activities demonstrate the importance of a scientific evidence base for the development of policies, including assessment and management of the human environment.

IV. Climate change and climate variability

40. There is currently much debate about the extent to which recently observed changes in climate can be attributed to human activities. This is complicated by the fact that climate varies naturally from year to year and decade to decade; thus long-term human-induced warming has to be distinguished from this natural background — wherein lies the challenge of extracting the consequences of human-induced climate change at regional and local levels from those due to natural climate variability. It has been argued that climate change could lead to significant changes in the frequency and intensity of extreme weather and climate events which could lead to disasters. It is not easy, however, to attribute cause or a particular role to climate change in any single extreme event once it has occurred.

A. Linkage between climate change and variability

41. If emissions of carbon dioxide and the other greenhouse gases continue increasing, the expected rise in global temperature will not be steady and uniform. Natural climate variability means that there will continue to be a mix of warmer and cooler years, and even decades, superimposed on a general, longer-term upward trend in global temperature, the longer trend being primarily due to anthropogenic interference with the climate system. This applies both globally and, more particularly, regionally. Recent climate models predict such spatially and temporally variable patterns of climate change across the surface of the earth and throughout the atmosphere and oceans, in response to given emissions scenarios. Indeed this pattern of interannual and spatial variability is exactly what has been observed in the climate record during the recent period of global warming.

42. The past 10 years or so have witnessed a major expansion of research into, and consequent understanding of, the predictability of the atmosphere on seasonal-to-interannual timescales. Exciting and useful results have already been obtained, with the

prospect of further valuable applications to follow. This progress is in itself equally significant for meeting the challenge of coping with the effects of climate change, since the impacts of climate change are likely to occur on all timescales, including those caused by changes in seasonal rainfall and temperature patterns. It must be emphasized that research and other studies relating to climate change and those relating to climate variability should not be treated as separate activities, either from the scientific or impacts viewpoints.

B. Role of systematic observations

43. The experience of the past 60 years has shown the absolute necessity of systematic observations of the earth's atmosphere and increasingly of the oceans and the land surface for weather forecasting. In more recent decades it has been demonstrated that further improvements in atmospheric, oceanographic and terrestrial observations will be required to predict and model climate change and variability, and to assess the extent and pattern of trends.

44. At its past three sessions, the Conference of the Parties (COP) to the FCCC has identified improved observations as a crucial underpinning for appropriate policy-making on climate change issues. In a series of recent decisions, the COP has highlighted the necessity for improvements in the geographical coverage, quantity, and quality of climate observations and has urged individual parties to address deficiencies in nationally funded climate-observing networks. Improvements in both ground-based and space-based observations are needed, and further integration of the two types, to produce consistent and coherent data sets, is imperative. The Global Climate Observing System (GCOS) was established in 1992 to facilitate the required improvements and the current status and recent developments related to the three domain-specific observing systems, that comprise GCOS atmospheric, oceanographic and terrestrial observations, are summarized in the background document entitled "Impacts of climate change and variability: assessment and adaptation".

45. The COP at its fifth session (1999) in Bonn, Germany, adopted a decision (decision 5/CP.5) to invite the GCOS secretariat, in consultation with relevant regional and international bodies, including the GEF, to organize regional workshops to identify specific and priority capacity-building needs. The first such workshop covering the South Pacific region was held in Samoa in August 2000. Another element contained in the decision relates to the adoption of the FCCC reporting guidelines for annex I Parties on global climate-observing systems. This marked an important achievement, since the guidelines request annex I Parties to provide uniform and comprehensive information about their activities related to the global climate-observing systems, development of observational networks, and activities related to support for non-Annex I Parties (i.e., developing countries). This information is to be provided in conjunction with the third national communication, which is due by November 2001.

C. Impacts of climate change and variability on human health

46. Activities to address the effect of weather and climate on health are accomplished within two elements of the "climate agenda": climate services for sustainable development; and climate impact assessment and response strategies to reduce vulnerability. In the second session of the Inter-Agency Committee on the Climate Agenda (IACCA), held in Geneva in 1998, the establishment of an Inter-Agency Network on Climate and Human Health was proposed, with a secretariat coordinated by WHO. Joint activities of the Inter-Agency Network began in 1999, among WHO, WMO and UNEP. The work focuses on three areas: capacity-building, information exchange, and research promotion.

47. Climate change could have an effect on the geographical range of many disease vectors and the incidence of such diseases as malaria and dengue fever. The impacts of year-to-year changes in the climate on the occurrence of weather extremes, and hence on the health of whole populations, were dramatically illustrated during recent episodes of the El Niño phenomenon. Droughts are more frequent and intense in some areas of the world, while in other areas, rainfall extremes can trigger food shortages, floods and landslides. Following the heavy rainfall in north-eastern Kenya and southern Somalia caused by the 1997-1998 El Niño event, the associated outbreak of Rift Valley fever killed large numbers of cattle, and even spread to humans.

48. Human beings respond physiologically to a number of atmospheric conditions, including

temperature, humidity, wind, solar radiation and air pollution. Excessive heat can cause death from heat strokes, and more people die from heart attacks during periods of excessive heat than during cooler periods. Urban populations are typically more vulnerable than their rural counterparts. WMO, WHO and UNEP are collaborating in developing demonstration heat-wave warning projects in major cities like Rome, Italy, and Shanghai. The projects can be replicated in other cities where inhabitants are especially threatened by the onset and prolongation of high ambient temperatures.

49. Airborne particles such as pollen, fungal spores and toxic emissions have significant implications for health. Acid rain and dry toxic deposits, which contaminate farmlands, forests, water sources and fish stocks, can adversely affect huge areas, depending on meteorological conditions. Local effects from pollution, such as smog and low-level ozone concentrations and the presence in the air of certain pollens have been linked to acute attacks of asthma and other respiratory conditions.

50. In addition to these factors, weather-related natural disasters, such as tropical cyclones, droughts, severe floods and abnormal monsoon conditions also have direct implications for the health of affected populations which may extend well beyond the period of the event itself.

51. Long-term changes in climate could also influence two foundations of public health systems: sufficient food, and safe and adequate drinking water. Because all plant and animal species are sensitive to the climate of their natural environment, agriculture and ecosystems would be affected by climate change. Some assessments suggest that the realization of current scenarios of climate change would lead to significant changes in the world's vegetation and animal species and to serious impacts on the availability and quality of freshwater for domestic, agricultural and industrial consumption. As well as affecting food supply, reduced water availability would have health implications. For example, it has been shown that, in times of water shortage, its use for cooking takes precedence over its use for hygiene.

D. Climate impact assessment

52. Impacts are difficult to quantify, and existing studies are limited in scope. Quantitative projections of the impacts of climate change on any particular location are difficult because regional-scale climate change projections are uncertain. Additionally, there is a limit to current understanding of many critical processes, and systems are subject to multiple climatic and non-climatic stresses, the interactions of which are not necessarily linear or additive. Climate change, like climate itself, can only be determined by comprehensive statistical analysis of weather and other geophysical records over an extended period of time.

1. Status of the third assessment report of IPCC

53. IPCC in its third assessment report seeks to address some of the problems and shortcomings mentioned above. As well as updating the scientific and technical aspects of its earlier assessments, the report will look at recent developments in the state of knowledge of climate change impact assessments, adaptation and vulnerability.

54. While building on previous assessments, the report departs from them in important respects. In comparison to previous assessments, greater attention is given to: climate change adaptation; multiple pressures on systems; links between climate change, sustainable development and equity; and characterization of the scientific knowledge and the confidence levels associated with key conclusions of the assessment. Areas of important new findings include detection of impacts, transient scenarios, vulnerability to changes in climate variability, and vulnerability to strongly non-linear, complex and discontinuous responses to climate change.

55. The report examines mitigation and adaptation in an integrated and balanced manner. Adaptation is a crucial component of impact assessment, given that the Kyoto Protocol provisions are unlikely to lead to the stabilization of greenhouse gases in the atmosphere. Adaptation, therefore, will become a necessary additional option as a mode of intervention. It is important to consider adaptive responses in order not to overemphasize the costs of climatic impacts. Maladapted responses can increase the costs of impacts relative to those when adaptive agents have perfect foresight or when adaptive responses are absent. Appropriate adaptations can reduce negative impacts or take advantage of new opportunities presented by changing climate conditions. In the report, greater attention has been focused on the societal determinants of adaptive capacity and vulnerability, which was not

the case in the second report or in the special report on the regional impacts of climate change, which was based on the second report.

2. Climate impacts and adaptation studies in countries with developing and transitional economies

56. Through a GEF-supported project on country studies of climate change impacts and adaptations assessment, UNEP carried out impacts and adaptation assessment studies in four countries; Cameroon, Antigua and Barbuda, Pakistan and Estonia.

57. The results of the country studies illustrate a diversity of climate impacts in developing countries and countries with economies in transition and suggest that climate impacts may differ significantly between these two groups of countries. Among the reasons for this are different ecological conditions, different levels of industrialization, and different degrees of dependency on the natural resource base. Taken together, the studies underscore the importance of considering impacts and adaptation strategies within the context of present-day realities and future trends. The studies placed heavy emphasis on the analysis of adaptation strategies for climate change. Until recently, adaptation had not been given much attention, because the primary focus had been on mitigation. The studies emphasize the need to address climate change through policy and planning.

58. The studies examined some of the actions and adjustments that are already being used to address climate variability. Responses to climate variability were seen as one way of adapting to future climate change which could well manifest itself in terms of enhanced variability. Several of the country studies expressed some degree of confidence regarding the potential for adaptation, especially if climate change occurs gradually. Resiliency emerged as an important factor in adapting to long-term climate change.

59. Addressing current problems is often seen as one way to increase overall resilience to climate change. An assessment of climate adaptation strategies reveals that economic reforms, policy changes, improved management and increased monitoring are important means of addressing long-term climate change. In fact, most of the adaptation measures identified in the studies could be considered necessary or beneficial, even in the absence of climate change. However, they require strategic actions, since few will occur autonomously.

E. Vulnerability and adaptation assessment

60. Considering the long life span of greenhouse gases in the atmosphere, adaptation to climate change, based on a precautionary approach, will be required, along with mitigation of the greenhouse gas emissions. New tools for vulnerability assessment that provide guidance on coping capacity and adaptation are thus required.

61. Vulnerability and adaptation are central to international policy on climate change, in both the FCCC and the Kyoto Protocol. Discussions relating to adaptation held during the sixth session of COP are likely to resume in early 2001. Stage II adaptation actions are being considered. The impact of climate change is unlikely to be evenly (or equitably) distributed around the world. Economic valuation of impacts should include equity. A simple approach would be to weigh impacts according to per capita income; thus, a given change in Bangladesh would have greater human impact than a similar change in the United States. However, economic estimates do not capture the true measure of vulnerability or the full range of "dangerous" interference in the climate system. More broadly based assessments of vulnerability which factor in exposure to natural hazards and consider non-market social, cultural, and institutional factors, in addition to economic estimates, are required.

62. It is useful to distinguish between adaptive measures or options (specific technologies available in the short run) and adaptive capacity (the longer-term ability to develop new options and deliver them to vulnerable populations). Similarly, sensitivity as distinct from vulnerability is related to resistance (the ability to resist change) and resilience (the ability to return to previous conditions after a perturbation).

V. The way forward: recommendations for reducing vulnerability, strengthening resilience and building adaptive capacity

63. In view of the recent findings of the IPCC in its third assessment report that there is evidence of substantial vulnerabilities to the projected climatic changes, particularly for poor populations and populations in coastal areas, there is need to draw greater attention to adaptive capacity and vulnerabilities of populations, natural systems and regions, and to links between climate change and sustainable development and equity. Also, in developing countries, there is need for substantial capacity-building so as to permit assessments of climate and environmental change, especially for quantitative methods of comparative assessment and decision support analyses.

64. Based on the need to monitor the state of the atmosphere and on the concepts and applications of vulnerability and adaptation assessments, and taking further into account the concept of resilience, the Commission may wish to consider such overarching issues as capacity-building, education and training, and public-awareness raising, and to recommend, particularly in developing countries with the support of the international community, analysis, development and implementation of the following elements:

(a) Infrastructure: Fundamental to building national capacity to cope with climate change and variability is the recognition that the atmosphere itself is a resource, subject to exploitation that can have both positive and negative consequences. Systems to measure and monitor the state of the atmosphere are therefore essential components of the infrastructure needed to enable societies to reach sustainable levels of development;

(b) Vulnerability (in the absence of climate change): Identifying the present distribution of vulnerable groups and the relative level of human development is the starting point for understanding vulnerability to climate change;

(c) Adaptive capacity: Although an analysis of prospects for adapting to climate change in the next few decades (particularly within a development cycle) is less certain than that of vulnerability in the absence of climate change, estimates can be made on the basis of trends in economic growth, development of human resources and other factors that could assist in the amelioration of potential adverse impacts;

(d) Assessments of resilience: Although there is a sense that resilience and vulnerability are opposites, there are cogent reasons for considering them separately. Objective methodologies for measuring resilience, either qualitatively or quantitatively, would be especially useful for assessing how and how well communities recover from particular disasters. Such analyses would be useful in defining appropriate methods for assessing the capacity for adapting to future climate changes;

(e) Climate change hazard: The risk of adverse climate impacts is less well known for individual countries than the conditions of vulnerability, resilience and even future adaptive capacity. It is likely that expert judgement will be required to rank the risks, even at the regional level.

65. To achieve the above objectives, the Commission may wish to recommend that the international community support the need to establish an international network for research on resilience, vulnerability and adaptation assessment. In building this network, it is essential to make it multidisciplinary in character, with representation from both the physical and social science viewpoints of climate and environmental change. Vulnerability involves many disciplines, and situations of vulnerability occur in all countries. While current research on the physical aspects of climate is extensive and well-coordinated, research on vulnerability — especially formal indicators — is fragmented. Specific research gaps include: linking local, sectoral assessments and national composite indices, understanding the cumulative effects of additional stresses caused by climate change, providing profiles of vulnerability that are relevant to diverse users and uses, and validating assessments. There is even less work being carried out on assessing resilience in any systematic fashion.

A. Capacity-building

66. Many countries need human and institutional capacity-building in climate impact research and disaster planning. Government agencies, policy

makers, and the wide range of users of climate and weather information need to be made aware of the many "not-so-obvious" ways in which climate variability and future climate change may affect their activities. Global-scale climate modelling and prediction efforts require resources that are currently available only in a few major centres in the industrialized world and, thus, there is a particular need to build capacity at the national and regional levels for downscaling the resulting global-scale predictions of climate variability and scenarios of climate change.

67. There is also a need for capacity-building in vulnerability assessment, as part of an international effort to develop quantitative indices of vulnerability to climate change and variability. The process requires global participation to ensure that the resulting methodologies meet the needs of the countries, especially the most vulnerable, and the needs of FCCC, and address the commitments of subsequent protocols of the Convention; and help advance work on Stage II adaptation.

68. UNEP, among other United Nations bodies, has undertaken a number of capacity-building activities, notably in the area of climate impact assessment and the clean development mechanism (CDM) of the Kyoto Protocol. In connection with the CDM, although capacity-building has been initiated and implemented, much remains to be done, especially in Africa. There is also need to build capacity to deal with land use, land-use change and forestry issues, especially if they should become elements of project activities under the CDM.

B. Education and training

69. Educational systems should encourage wider understanding and study of climate/society/environment interactions, because there is need for a better informed public on the consequences and impacts of climate variability and change. The Commission may wish to recommend that the international community step up training at all levels — primary, secondary and tertiary — in national educational systems. Some educational materials are available, such as *Climate and Human Health*, published by UNEP and WMO, and *Preparing for Drought*, published by UNEP. The book, *Coping with Aridity*, published by UNEP, based on a project with the Government of Namibia, a country highly vulnerable to drought, could serve as an example of reference material for the region on how to prepare for droughts. It examines how communities have coped with drought in the past, and how the experience may apply in developing strategies to cope with future droughts. It was an attempt to integrate other initiatives then in place to arrive at a drought plan for the country. Since the citizens of Namibia carried out most of the work, the project was a source of considerable learning. The interdisciplinary nature of the project demonstrated the need for synergistic approaches, so essential in addressing such intricate environmental issues.

70. The Commission may also wish to recommend that the international community provide enhanced assistance in education and training. A good example of such cooperation is the United Nations Foundation-supported project on the El Niño phenomenon, which considered, among other issues, the possibility of developing a "climate affairs" curriculum at the university level, where a multidisciplinary programme could be developed to address the problem of climate impacts, climate economics, climate policy and the social implications of climate-related disasters. A number of universities have shown interest. The ultimate goal of the climate affairs course would be to provide an understanding of: how the atmosphere and ocean interact to affect climate; how various types of land use affect and are affected by climate; how human activities affect the chemistry of the atmosphere; and how decision and policy makers, from the local to international levels, might cope with variable and changing climate.

C. Public awareness

71. The success of the notion of sustainable development and the international environmental conventions on ozone, climate change, biodiversity and desertification will continue to depend, to a large extent, on the support of the general public, key constituencies and interest groups. Emissions will be reduced and adaptations to impacts of climate change will be accepted only if people fully understand climate change and variability risks, the adaptation in response, and the voluntary actions that they can take at the personal and community levels. In this regard, the Commission may wish to recommend that donor countries expand their assistance to countries and

international organizations in promoting awareness of climate change issues by:

(a) Developing factual and informational materials to disseminate the often highly technical findings of in-depth investigations, such as those of the IPCC, more effectively to a wide range of decision makers and to the general public;

(b) Providing special support material to the media and through targeted media briefings on special topics;

(c) Supporting the preparation of materials especially useful in schools and other educational environments;

(d) Conducting specialist training programmes in developing countries to bring the advances in research and teaching institutions of the industrialized world to the developing world and, in particular, to explore how best to adapt those advances to local needs and circumstances;

(e) Conducting multidisciplinary workshops and forums to ensure that the results of scientific research and technological developments are effectively transferred into applications at the user and community levels;

(f) Establishing linked web sites and using other electronic media (e.g., CD-ROM) which provide access to information on different aspects of climate, climate change and variability, and sustainable development to a wide range of users.

Notes

[1] A/AC.237/18 (Part II)/Add.1 and Corr.1, annex I.

[2] UNEP, Environmental Law and Institution Programme Activity Centre, June 1992.

[3] A/49/84/Add.2, annex, appendix II.

[4] FCCC/CP/7/Add.1, decision 1/CP.3.